



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.10.2022 Bulletin 2022/43

(21) Application number: **21382335.4**

(22) Date of filing: **19.04.2021**

(51) International Patent Classification (IPC):
C10M 111/02 ^(2006.01) **C10M 169/04** ^(2006.01)
C10N 30/00 ^(2006.01) **C10N 30/06** ^(2006.01)
C10N 30/12 ^(2006.01) **C10N 40/00** ^(2006.01)
C10N 20/00 ^(2006.01)

(52) Cooperative Patent Classification (CPC):
C10M 111/02; C10M 169/04; C10M 2207/2835;
C10M 2207/4045; C10M 2219/024;
C10M 2219/044; C10M 2219/066; C10N 2020/081;
C10N 2030/06; C10N 2030/12; C10N 2030/26;
C10N 2030/64; C10N 2040/38

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **BIODEGRADABLE LUBRICANT COMPOSITION**

(57) The present invention relates to a lubricant composition comprising 90-99.5 wt% of a base oil and 0.5-10 wt% of an additive, wherein the base oil consists of a mixture of castor oil and a triester of trimethylolpropane with octanoic acid and decanoic acid. The present inven-

tion also relates to the use of the composition for the lubrication of any mechanical device and, particularly, for the lubrication of bicycle chains. The lubricant composition is environmentally friendly, as it is based on biodegradable materials and renewable sources.

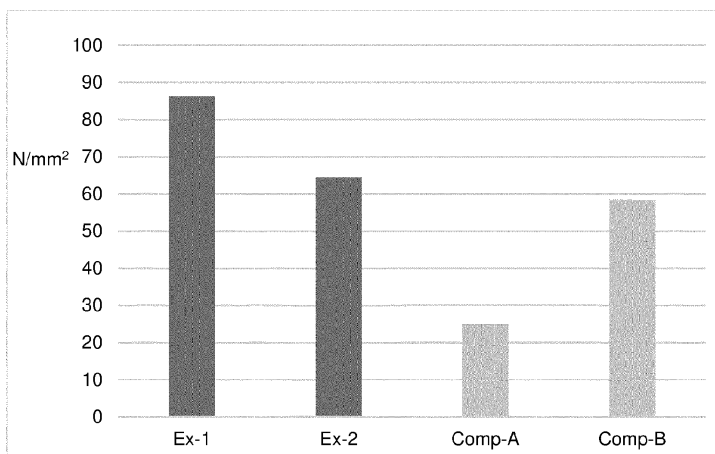


FIGURE I

Description**Technical field**

[0001] The present invention relates to the field of lubricant compositions, and more particularly to biolubricants.

Technical background

[0002] Lubricants are widely used for many applications, either industrial, commercial or personal, typically for whatever device whose functioning involves some friction between metallic surfaces. Among the common functions of lubricants are to decrease friction, protect against corrosion and wear or to remove heat, for example. Lubricants are also used as a media for transmitting energy, as hydraulic fluids.

[0003] As is well-known, lubricant formulations are based on oils and greases and, traditionally, during many decades, lubricant research and development has been focused on petroleum-based oils. However, as a large percentage of all lubricants worldwide enters the environment, petroleum-based lubricants are considered a threat due to their high toxicity and low biodegradability. For this reason, there is a growing interest in developing lubricants which are biodegradable and which are mainly based on renewable raw materials. These lubricants are frequently referred to as biolubricants or bio-based lubricants.

[0004] Vegetable oils are commonly used as biolubricants, including oils derived from avocado, rapeseed, olive, palm, peanut, safflower, sesame, soybean or sunflower, among many other. They have the advantage of having excellent biodegradability and being readily available from renewable sources. Furthermore, in general, they show good lubricity and wear properties with high viscosity index and flash point. However, lubricants based on vegetable oils also have drawbacks, for example, lack of sufficient oxidative stability, limited temperature range, unpleasant smell, poor compatibility with paints and sealants and flushing propensity because of their low viscosity, for example (Reeves et al., A review on the science and technology of natural and synthetic biolubricants, J. Bio. Trio Corros., 2017, 3:11; Mobarak et al., The prospects of biolubricants as alternatives in automotive applications, Renew. Sustain. Energy Rev., 2014, 33, 34-43). Other widely used lubricants are synthetic esters which can be synthesized from long-chain alcohols and acids. There are many choices of acids and alcohols available for the production of synthetic esters, including monovalent alcohols and polyols such as neopentyl glycol, pentaerythritol, trimethylolpropane, trimethylolhexane or trimethylolethane, among many others; suitable organic acids include C₅-C₁₈ monoacids and diacids such as adipic acid, azelaic acid, sebacic acid or dodecanedioic acid, for example, among others. These synthetic esters show low toxicity and excellent biodegradability. Furthermore, they often show improved performance compared to natural oils due to a more uniform molecular structure and the use of different alcohols (Reeves *et al.*, *op.cit.*).

[0005] Lubricant compositions frequently include also some minor additives to improve the properties of base oil. Typical additives are antioxidants, corrosion inhibitors, anti-wear additives or pour point depressants, for example. These additives included in biolubricants should also not be harmful for the environment.

[0006] Environmental concerns and the more restrictive environmental regulations have boosted interest in developing biolubricants with improved performance and/or better tailored for specific applications.

[0007] There are many disclosures in the prior art concerning the development of improved biolubricant formulations. They are based on different approaches, for example, on the combination of different vegetable oils, or on the use of chemically-modified vegetable oils, or on the preparation of new biolubricants by transesterification of vegetable oils with different polyols, or on the use of new additives in the biolubricant formulations, among many other proposals.

[0008] However, and despite the many proposals available, there remains the need of providing biolubricant formulations with better lubricant performance, which are substantially biodegradable, based on renewable sources, that are non-toxic and suitable for specific applications.

Object of the invention

[0009] The object of the present invention is a lubricant composition.

Another aspect of the invention is the use of the composition for the lubrication of mechanical devices.

Description of the drawings

[0010] Figure 1 shows the results of the anti-wear performance test disclosed in Example 3.1. The anti-wear performance is represented by the calculated Brugger value (in N/mm²). The samples assayed are the compositions of the invention disclosed in Examples 1 and 2 and two commercial lubricant compositions as comparators (Comp-A and Comp-B).

Detailed description of the invention

[0011] The object of the present invention is a lubricant composition comprising:

- 5 a) 90-99.5 wt% of a base oil and
 b) 0.5-10 wt% of an additive;

wherein the base oil consists of a mixture of castor oil and a triester of trimethylolpropane with octanoic acid and decanoic acid.

10 **[0012]** The authors of the present invention have surprisingly found that the specific combination of a natural vegetal oil, namely, castor oil, and a triester derived from trimethylolpropane with C8/C10 fatty acids provides excellent lubricant properties. The lubricant composition is environmentally friendly as it is biodegradable and greatly based on renewable sources.

[0013] In one embodiment, the lubricant composition consists of the components a) and b), as disclosed above; in this case, therefore, the sum of the percentages of a) and b) amounts to 100.

[0014] Along the present description, as well as in the claims, the terms "a," "an," or "the" not only include aspects with one member (singular), but also include aspects with more than one member (plural).

[0015] The terms "about" or "approximately" referred to amounts, as used herein, are meant to include the exact amount and also a certain deviation around the stated amount, namely of $\pm 5\%$.

20 **[0016]** Unless stated otherwise, the percentages are meant to be by weight (wt%).

The numerical ranges disclosed herein are meant to include any number falling within the ranges and also the lower and upper limits.

[0017] Along the present description, the term "biolubricant" is used to refer to the lubricant composition of the present invention. This term denotes that the composition is composed of biodegradable substances, mainly obtained from renewable sources (as castor oil) and which are considered not harmful to the environment.

Base oil

[0018] The base oil amounts to between 90 and 99.5 % of the total weight of the lubricant composition.

30 **[0019]** Preferably, the base oil amounts to about 94-99 wt% of the composition, and more preferably to about 96-98 wt% of the composition.

[0020] This base oil consists of a mixture of castor oil and a triester of trimethylolpropane with octanoic acid and/or decanoic acid

Castor oil

[0021] Castor oil, as is well known, is a vegetable oil obtained from the seeds of the castor plant (*Ricinus communis*). It is a mixture of triesters of glycerin with fatty acids, mostly with ricinoleic acid, which amounts about 89% of total fatty acids. Ricinoleic acid, also called (*R*)-12-hydroxy-9-*cis*-octadecenoic acid, is a linear C₁₈ fatty acid with a *cis*-double bond between carbons 9 and 10 and a hydroxy group located at carbon 12. Other minor fatty acids are linoleic acid, oleic acid, stearic acid, palmitic acid, dihydroxystearic acid, linolenic acid and eicosanoic acid (Ogunniyi D.S., Castor oil: A vital industrial raw material, Bioresource Technol., 2006, 1086-1091). All possible grades of castor oil, i.e. different variations in the fatty acid content, are included within the scope of the invention.

[0022] Castor oil is widely available from many commercial sources.

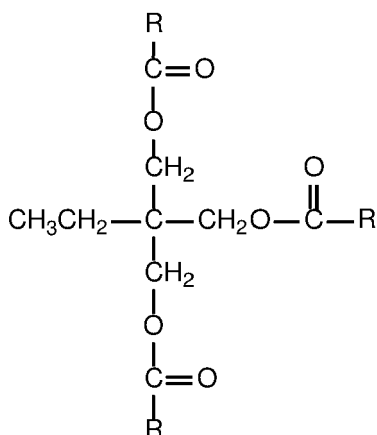
45 **[0023]** The percentage of castor oil in the base oil is generally comprised between 70 and 90 wt%, preferably between 75 and 88 wt% and more preferably comprised between 78 and 85 wt%, referred to the total weight of the base oil.

Triester of trimethylolpropane with octanoic acid and decanoic acid

50 **[0024]** The second component of the base oil in the lubricant composition is a triester ester of trimethylolpropane (TMP) with octanoic acid (C8 carboxylic acid: also known as caprylic acid) and decanoic acid (C10 carboxylic acid: also known as capric acid).

[0025] The percentage of this triester of trimethylolpropane in the base oil is generally comprised between 10 and 30 wt%, preferably comprised between 12 and 25 wt% and more preferably is comprised between 15 and 22 wt%, referred to the total weight of the base oil.

55 **[0026]** This triester is a mixed ester of trimethylolpropane with a mixture of octanoic acid and decanoic acid, i.e., it has the following formula:



wherein R is a C₇ or a C_g linear hydrocarbon chain.

[0027] All different percentages of octanoic and decanoic acids in the triester may be suitable. Generally, the percentage of octanoic acid is comprised between 30% and 80%, preferably comprised between 40% and 70% and more preferably comprised between 50% and 60%, referred to the total amount of fatty acids. The percentage of decanoic acid is generally comprised between 20% and 70%, preferably comprised between 30% and 60%, more preferably comprised between 40% and 50%, referred to the total amount of fatty acids.

[0028] The TMP triester is typically formed by a mixture of different triesters, namely, a triester of TMP with octanoic acid only (TMP-3C8), a mixed triester with 2 mols of octanoic acid and 1 mol of decanoic acid (TMP-2C8-1C10), a mixed triester with 1 mol of octanoic acid and 2 mols of decanoic acid (TMP-1C8-2C10) and a triester with decanoic acid only (TMP-3C10). Any different proportions of said four possible triesters are suitable and are included within the scope of the invention.

[0029] In one embodiment, for example, the molar proportion of the triester TMP-3C8 is in the range of about 15-25%, the molar proportion of the triester TMP-2C8-1C10 is in the range of about 40-50%, the molar proportion of the triester TMP-1C8-2C10 is in the range of about 25-35% and the molar proportion of the triester TMP-3C10 is in the range of about 2-10%.

[0030] The triester of trimethylolpropane with octanoic acid and decanoic acid can be prepared by common synthetic methods, well-known in the art, by simple esterification reaction of the trimethylolpropane alcohol with a suitable mixture of octanoic and decanoic acids, usually in the presence of a catalyst, for example, a tin compound.

[0031] Furthermore, several triesters of trimethylolpropane with octanoic acid and decanoic acid are also commercially available, for example, the products WAGLINOL[®] 3/13480 of the company IQL (Industrial Química Lasam), or the product ZELEC[®] 887 of the company Stepan, among others.

Additive

[0032] The lubricant composition of the invention comprises from 0.5 to 10 wt% of an additive.

[0033] Preferably, the additive amounts to about 1-6 wt% of the composition, and more preferably to about 2-4 wt% of the composition.

[0034] The additive may be selected from an antioxidant, a corrosion inhibitor, an anti-wear additive, a viscosity improver, a pour point depressant and mixtures thereof.

[0035] The purpose of antioxidant additives, for example, is to delay or prevent the oxidation process by protecting the lubricant from oxidative degradation. Suitable antioxidant additives may be of natural origin, such as tocopherols, esters of gallic acid, citric acid, citric acid derivatives, L-ascorbic acid or ascorbyl palmitate, among others. Antioxidants may be also synthetic, for example, bis(disubstituted dithiocarbamates), particularly methylene bis(dialkyldithiocarbamates); dithiocarbamate esters; sterically hindered phenols, such as butylated hydroxytoluene (BHT), 2,6-di-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, 6,6'-di-*tert*-butyl-4,4'-butylidenedi-m-cresol, mono-*tert*-butylhydroquinone, 4,4'-methylenebis(2,6-di-*tert*-butylphenol), octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate, or thiodiethylene bis[3-(3,5-di-*tert*-butyl-4-hydroxyphenyl)propionate], among many others; or aromatic amines, in particular, dialkylated diphenylamines such as butyl-octyl-diphenylamine, dibutyldiphenylamine, or dioctyldiphenylamine, among others, or alkylated phenyl alpha naphthylamines.

[0036] Preferred antioxidants are methylene bis(dialkyldithiocarbamates), butylated hydroxytoluene, 2,6-di-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, mono-*tert*-butylhydroquinone, 4,4'-methylenebis(2,6-di-*tert*-butylphenol) and octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate; more preferred antioxidants are methylene bis(dialkyldithiocarbamates), 4,4'-methylenebis(2,6-di-*tert*-butylphenol) and octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate.

[0037] When there is an antioxidant additive it is generally in an amount comprised between 0.1 wt% and 6 wt%, preferably comprised between 0.5 wt% and 5 wt%, more preferably comprised between 0.75 and 3 wt%, relative to the total weight of the lubricant composition.

[0038] The purpose of corrosion inhibitors is to avoid rust in the metallic components in contact with the lubricant composition. There are many substances disclosed in the art which can be used as corrosion inhibitors (see for example Z. Tang, A review of corrosion inhibitors for rust preventive fluids, Curr. Opin. Solid State Mater. Sci., 2019, 23, 100759 or in the book chapter M.T. Costello, Corrosion Inhibitors and Rust Preventives, in: Lubricant Additives. Chemistry and Applications, Second Edition, L.R. Rudnick Ed., CRC Press, 2009, Chapter 17, 421-444). Some suitable corrosion inhibitors are, for example, dicarboxylates, in particular, succinic acid derivatives; alkyl amines; amino acids; sulfonic acid esters; derivatives of some nitrogen containing heterocycles, for example, imidazoline, thiazole, thiadiazole or benzothiazole, such as dimercaptothiadiazoles or mercaptobenzothiazole derivatives; among many others.

[0039] A preferred type of corrosion inhibitor is a succinic acid derivative.

[0040] Another preferred type of corrosion inhibitor is a sulfonic acid ester prepared by reaction of benzenesulfonic acids (mono-, di- or trialkyl benzenesulfonic acids) with a methyl ester of an epoxidized unsaturated fatty acid, as described in the European patent application EP-A-0557839.

[0041] When there is a corrosion inhibitor in the formulation, it is generally in an amount comprised between 0.1 wt% and 4 wt%, preferably comprised between 0.2 and 2 wt%, and more preferably comprised between 0.5 wt% and 1.5 wt%, relative to the total weight of the lubricant composition.

[0042] The purpose of anti-wear additives is to protect materials against wear. There are also many substances disclosed in the art which can be used as anti-wear additives (for example, as disclosed in L.O. Farnig, Ashless Anti-wear and Extreme-Pressure Additives, in: Lubricant Additives. Chemistry and Applications, Second Edition, op. cit., Chapter 8, 213-249). Some typical anti-wear additives are, for example, triesters of phosphoric acid or thiophosphoric acid, which may be alkyl esters, aryl esters, or mixed alkyl aryl esters, for example, tricresyl phosphates or trixylenyl phosphates or triphenyl phosphorothionate (TPPT); amine salts of acid phosphoric acid esters; dithiophosphates; dithiocarbamates, such as methylene bis(dialkyldithiocarbamates); or sulfurized fatty acid esters; among others.

[0043] Some preferred anti-wear additives are methylene bis(dialkyldithiocarbamates) and sulfurized fatty acid esters.

[0044] When there is an anti-wear additive in the formulation, it is generally in an amount comprised between 0.1 wt% and 6 wt%, preferably comprised between 0.5 wt% and 5 wt%, relative to the total weight of the lubricant composition.

[0045] The viscosity improvers are usually thickeners, used to adjust the viscosity of the composition. Typical viscosity improvers are, for example, esters of polymethacrylic acid with hydrocarbon side chains of different lengths (see, for example, B.G. Kinker, Polymethacrylate viscosity modifiers and pour point depressants, in: Lubricant Additives. Chemistry and Applications, Second Edition, op. cit., Chapter 11, 315-337).

[0046] When there is a viscosity improver, it is in an amount comprised between 0.1 wt% and 5 wt%, relative to the total weight of the composition.

[0047] Pour point depressants are polymeric molecules that can be added to improve the flow properties of the biolubricant. Examples of pour point depressants are acrylates, alkylated styrenes, alpha olefins, ethylene/vinyl acetates, methacrylates, styrene/maleic anhydrides, and vinyl acetate/fumarates.

[0048] The inventors found that the base oil used had excellent lubricant properties which made it not necessary to use many additives. For example, the viscosity and pour point of the base oil are optimal so, in general, viscosity improvers or pour point depressants are not necessary.

[0049] In one embodiment, the additive is selected from an antioxidant, a corrosion inhibitor, an anti-wear additive and mixtures thereof.

[0050] In one embodiment of the invention the additive comprises:

- an anti-wear additive in an amount comprised between 0.2 wt% and 3 wt%, preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition;
- an antioxidant additive in an amount comprised between 0 wt% and 3 wt%, preferably comprised between 0.2 wt% and 3 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition.

[0051] In one more particular embodiment the additive consists of the above ingredients.

[0052] In one particular embodiment, the anti-wear additive is selected from methylene bis(dialkyldithiocarbamates) and sulfurized fatty acid esters.

In one particular embodiment, the antioxidant additive is selected from methylene bis(dialkyldithiocarbamates), 4,4'-methylenebis(2,6-di-*tert*-butylphenol) and octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate.

[0053] In one particular embodiment, the corrosion inhibitor is selected from succinic acid derivatives and sulfonic acid esters.

[0054] In the practice, some additives may advantageously perform more than one function. As used herein, the terms anti-wear additive, antioxidant, corrosion inhibitor, viscosity improver or pour point depressant are meant to include also those substances having additional functions.

[0055] For example, some additives simultaneously perform an antioxidant and anti-wear function (anti-wear/antioxidant additive).

[0056] In one embodiment of the invention, the additive comprises:

- an anti-wear/antioxidant additive in an amount comprised between 0.3 wt% and 6 wt%, preferably comprised between 0.5 wt% and 4 wt% and more preferably comprised between 1 wt% and 3 wt%; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%.

[0057] In one more particular embodiment the additive consists of the above ingredients.

[0058] In one particular embodiment, the anti-wear/antioxidant additive is a methylene bis(dialkylthiocarbamate). This type of additives is known to provide antioxidant and anti-wear properties. One particularly preferred additive is methylene bis(dibutylthiocarbamate).

[0059] In one particular embodiment, the corrosion inhibitor is selected from succinic acid derivatives and sulfonic acid esters.

Preparation of the lubricant composition

[0060] The lubricant composition can be prepared by mixing all the components, typically, by first mixing the two components of the base oil, i.e., castor oil and the triester of trimethylolpropane with octanoic acid and decanoic acid, to obtain a homogeneous mixture, and then adding the additives under stirring. Other mixing order of the components is also suitable.

Use of the lubricant composition

[0061] Another aspect of the invention is the use of the lubricant composition of the invention for the lubrication of mechanical devices.

[0062] The biolubricant composition of the present invention can be used for any lubricating application, either for industrial machinery or for any other purpose. As shown in the tests performed in Example 3, the lubricant composition of the present invention shows excellent performance in anti-wear, water repellency, rust protection, paint compatibility and dirt repelling tests.

[0063] In particular, as shown in Example 3.1, the anti-wear properties of the lubricant of the present invention are optimal. Compared to two standard commercial products, the lubricant compositions according to the present invention show the best results in the anti-wear test.

[0064] Furthermore, as shown in Example 3.2, the lubricant composition of the present invention shows also excellent water-repellent properties. This characteristic is important to ensure the durability of the lubricated parts, because the presence of water can have harmful effects on machine components, and also to ensure the stability of the lubricant composition itself, as the presence of water can also lead to lubricant oxidation, hydrolysis or some undesired reaction of the components.

[0065] Another aspect to assess the performance of lubricants, particularly those intended to be used in outdoor applications which involve contact with the environment, is its dirt repelling efficiency, to avoid getting contaminated with dust or other particles present in the environment.

[0066] Some of the properties found for the biolubricant composition of the present invention make it particularly suitable, in particular, for chain lubrication of bicycles.

[0067] Thus, for example, the capacity to repel water is particularly important for lubricants for the bicycle industry, in order to prevent chain rusting and also for their use in extreme weather conditions. Also, the dirt-repelling effect, along with the anti-wear efficiency and the durability of the lubricant itself, may be relevant for lubricants to be used for bicycle chains in order to increase chain lifetime.

[0068] Another aspect of the invention is, therefore, the use of the lubricant composition of the invention for the lubrication of bicycle chains. It includes typically mechanical bicycles and electric bicycles (e-bikes), and also motorcycles.

[0069] Other suitable properties of the lubricant composition of the present invention relate to its rust protection performance and paint compatibility, as shown in Examples 3.3 and 3.4, which may be particularly relevant also for the lubrication of bike chains. Furthermore, the lubricant composition is environmentally friendly as it is composed of sub-

stantially biodegradable components, which are nontoxic to the environment, and mainly based on renewable sources. It makes also the composition of the invention particularly suited for the lubrication of bicycle chains, as part of lubricant may be released to the environment during its use.

[0070] The present invention may be defined by the following embodiments:

1.- A lubricant composition comprising:

- a) 90-99.5 wt% of a base oil and
- b) 0.5-10 wt% of an additive;

wherein the base oil consists of a mixture of castor oil and a triester of trimethylolpropane with octanoic acid and decanoic acid.

2.- The lubricant composition according to embodiment 1, characterised in that it consists of the base oil a) and the additive b).

3.- The lubricant composition according to embodiments 1 or 2, characterised in that it comprises 94-99 wt% of base oil, preferably it comprises 96-98 wt% of base oil.

4.- The lubricant composition according to any one of embodiments 1 to 3, characterised in that the percentage of castor oil in the base oil is comprised between 70 and 90 wt%, preferably between 75 and 88 wt% and more preferably between 78 and 85 wt%; and the percentage of the triester of trimethylolpropane with octanoic acid and decanoic acid in the base oil is comprised between 10 and 30 wt%, preferably between 12 and 25 wt% and more preferably between 15 and 22 wt%, referred to the total weight of base oil.

5.- The lubricant composition according to any one of embodiments 1 to 4, characterised in that the percentage of octanoic acid in the triester or trimethylolpropane is comprised between 30% and 80%, and the percentage of decanoic acid is comprised between 20% and 70%, referred to the total amount of fatty acids in the triester.

6.- The lubricant composition according to any one of embodiments 1 to 5, characterised in that the triester of trimethylolpropane (TMP) with octanoic acid (C8) and decanoic acid (C10) consists of a mixture of four triesters, wherein the molar proportion of the triester TMP-3C8 is in the range 15-25%, the molar proportion of the triester TMP-2C8-1C10 is in the range 40-50%, the molar proportion of the triester TMP-1C8-2C10 is in the range 25-35% and the molar proportion of the triester TMP-3C10 is in the range 2-10%.

7.- The lubricant composition according to any one of embodiments 1 to 6, characterised in that it comprises 1-6 wt% of additive, preferably it comprises 2-4 wt% of additive.

8.- The lubricant composition according to any one of embodiments 1 to 7, characterised in that the additive is selected from an antioxidant, a corrosion inhibitor, an anti-wear additive, a viscosity improver, a pour point depressant and mixtures thereof.

9.- The lubricant composition according to embodiment 8, characterised in that the additive is selected from an antioxidant, a corrosion inhibitor, an anti-wear additive and mixtures thereof.

10.- The lubricant composition according to embodiment 9, characterised in that the additive comprises:

- an anti-wear additive in an amount comprised between 0.2 wt% and 3 wt%, preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition;
- an antioxidant additive in an amount comprised between 0 wt% and 3 wt%, preferably comprised between 0.2 wt% and 3 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition.

11.- The lubricant composition according to embodiment 10, characterised in that the additive consists of:

- an anti-wear additive in an amount comprised between 0.2 wt% and 3 wt%, preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition;
- an antioxidant additive in an amount comprised between 0 wt% and 3 wt%, preferably comprised between 0.2 wt% and 3 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition.

12.- The lubricant composition according to any one of embodiments 8 to 11, characterised in that the antioxidant is selected from tocopherols, esters of gallic acid, citric acid, citric acid derivatives, L-ascorbic acid, ascorbyl palmitate, bis(disubstituted dithiocarbamates), dithiocarbamate esters, butylated hydroxytoluene (BHT), 2,6-di-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, 6,6'-di-*tert*-butyl-4,4'-butylidenedi-m-cresol, mono-*tert*-butylhydroquinone, 4,4'-methylenebis(2,6-di-*tert*-butylphenol), octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate, or thiodiethylene bis[3-(3,5-di-*tert*-butyl-4-hydroxyphenyl)propionate], butyl-octyl-diphenylamine, dibutyldiphenylamine, or dioctyldiphenylamine and alkylated phenyl alpha naphthylamines.

13.- The lubricant composition according to embodiment 12, characterised in that the antioxidant is selected from methylene bis(dialkyldithiocarbamates), butylated hydroxytoluene, 2,6-di-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, mono-*tert*-butylhydroquinone, 4,4'-methylenebis(2,6-di-*tert*-butylphenol) and octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate, preferably is selected from methylene bis(dialkyldithiocarbamates), 4,4'-methylenebis(2,6-di-*tert*-butylphenol) and octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate.

14.- The lubricant composition according to any one of embodiments 8 to 13, characterised in that the anti-wear additive is selected from triesters of phosphoric acid or thiophosphoric acid, amine salts of acid phosphoric acid esters, dithiophosphates, methylene bis(dialkyldithiocarbamates) and sulfurized fatty acid esters.

15.- The lubricant composition according to embodiment 14, characterised in that the anti-wear additive is selected from methylene bis(dialkyldithiocarbamates) and sulfurized fatty acid esters.

16.- The lubricant composition according to embodiment 9, characterised in that the additive comprises:

- an anti-wear/antioxidant additive in an amount comprised between 0.3 wt% and 6 wt%, preferably comprised between 0.5 wt% and 4 wt% and more preferably comprised between 1 wt% and 3 wt%; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%.

17.- The lubricant composition according to embodiment 16, characterised in that the additive consists of:

- an anti-wear/antioxidant additive in an amount comprised between 0.3 wt% and 6 wt%, preferably comprised between 0.5 wt% and 4 wt% and more preferably comprised between 1 wt% and 3 wt%; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%.

18.- The lubricant composition according to embodiments 16 or 17, characterised in that the anti-wear/antioxidant additive is a methylene bis(dialkyldithiocarbamate), preferably is methylene bis(dibutyldithiocarbamate).

19.- The lubricant composition according to any one of embodiments 8 to 18, characterised in that the corrosion inhibitor is a succinic acid derivative or a sulfonic acid ester, preferably is an alkylbenzenesulfonic acid ester with an epoxidized unsaturated fatty acid.

20.- Use of the lubricant composition according to any one of embodiments 1 to 19 for the lubrication of mechanical devices.

21.- Use according to embodiment 20, for the lubrication of bicycle chains.

ExamplesExample 1.-Lubricant composition

[0071] A lubricant composition according to the invention was prepared with the ingredients listed in the following table:

Ingredients	Function	Amount (wt%)
Castor oil	Base oil	78.5
Triester of trimethylolpropane with octanoic acid and decanoic acid	Base oil	18.5
Methylenebis(dibutyldithiocarbamate)	Anti-wear / antioxidant additive	2
Alkylbenzenesulfonic acid ester with epoxidized rapeseed oil fatty acids	Corrosion inhibitor	1

[0072] The triester of trimethylolpropane with octanoic acid and decanoic acid was a mixture of triesters with the approximate molar proportion (TMP-3C8) : (TMP-2C8-1C10) : (TMP-1C8-2C10) : (TMP-3C10) of 22:44:29:5.

[0073] The two base oil components were first mixed and the additives were next added and thoroughly mixed. The formulation was a viscous oil with no odour.

Example 2.-Lubricant composition

[0074] A lubricant composition according to the invention was prepared with the ingredients listed in the following table:

Ingredients	Function	Amount (wt%)
Castor oil	Base oil	79
Triester of trimethylolpropane with octanoic acid and decanoic acid	Base oil	19
Sulfurized fatty acids methyl esters from vegetable-oil	Anti-wear additive	2

[0075] The triester of trimethylolpropane with octanoic acid and decanoic acid was the same used in Example 1.

[0076] The two base oil components were first mixed and the additives were next added and thoroughly mixed. The formulation was a viscous oil with no odour.

Example 3.-Assays to assess the performance of the lubricant compositions

3.1. Anti-wear performance

[0077] The anti-wear performance of the lubricant formulation was measured on a Brugger test machine, which is a standardized method (DIN 51347 parts 1 and 2) based on the friction conditions in the contact zone between a friction ring and a test cylinder. All tests were conducted with a 25 mm ring and a test cylinder of 18 mm x 18 mm. The test cylinder is pressed against the ring by applying a normal force of 400 N. Approximately 8 ml of sample were placed between the roller and the ring; then the ring was allowed to rotate during 30 seconds. After that, the elliptical wear scar produced on the roller's surface was measured. The two diameters (a and b) of the ellipse were used to calculate the Brugger value (N/mm²) through the formula:

$$\text{Brugger value (N/mm}^2\text{)} = \frac{4 \times 400}{a \times b \times \pi}$$

[0078] For each sample, the procedure was repeated five times and the mean value was calculated. The higher the Brugger value the better anti-wear capacity.

The samples tested were the lubricant compositions of Examples 1 and 2, and two commercial bicycle chain lubricants as shown in the following table:

Sample	Brugger value (N/mm ²) Mean
Example 1	86.22
Example 2	64.45
Comp-A	24.96
Comp-B	58.59

[0079] The comparative formulations Comp-A and Comp-B were commercial lubricant compositions.

[0080] The mean values are represented in the graph of Figure 1.

It can be observed that the best results in this test are obtained with the lubricant compositions of the present invention.

3.2. Water repellency (Crackle Test)

[0081] The objective of this assay was to assess the capacity of the lubricant composition to repel water.

[0082] For this assay, 5 ml of each tested lubricant composition were taken and mixed with 1 wt% and 3 wt% of added water, which was incorporated into the composition by stirring for 2 minutes.

[0083] A steel panel was placed in the oven at 160 °C for 5 minutes. Then, the panel was removed from the oven and 1 ml of each tested sample was placed on it. The appearance of bubbles was assessed and each sample was rated according to the following scale:

1. There is no visible or audible change. No free or emulsified water.
2. Very small bubbles (0.5 mm) are produced and quickly disappear.
3. Bubbles of about 2 mm are produced, which enlarge to about 4 mm and quickly disappear.
4. Violent and audible bubbling, bubbles of about 2-4 mm are produced and released.

The results are shown in the following table. The comparative formulations (Comp-A and Comp-B) are the same used in the anti-wear performance test (Example 3.1).

Tested composition	Crackle test score	
	1 % water	3 % water
Example-1	3	3
Example-2	3	3
Comp-A	1	1
Comp-B	3	3

[0084] The same water-repellent effect was found for both water content tested, i.e. 1% and 3%.

The lubricant composition of the invention provided good water-repellent effect.

3.3. Rust protection on Steel

[0085] In order to assess the rust protection on steel of the lubricant compositions, a test based on ASTM D665 was performed.

[0086] The procedure comprised the following steps:

1. A solution of 25 ml of the tested lubricant and 5 ml of tap water was prepared.
2. The solution was heated to a temperature of 60 °C, under stirring at 1400 rpm with a magnetic stirrer bar.
3. A steel panel was cleaned with hexane to eliminate any particle on the surface.
4. Half of the steel panel was submerged into the solution, maintaining the stirring.
5. After 30 minutes the steel panel was extracted from the solution and was inserted into a jar with a solution of 2g of NaCl in 100 mL of tap water, and the jar was closed to air.
6. After 24h, the panel was removed from the jar and was placed inside the oven at 80 °C for drying.
7. After 1 h of drying, the appearance of corrosion in the panel was visually evaluated.

[0087] The lubricant composition of Examples 1 and 2 was subjected to this test. No rust was observed with the composition of Example 1 with virtually no change in the appearance of the panel after the test. Some rust was observed with the composition of Example 2.

[0088] The compatibility between the lubricant and the paint found in some metallic components was tested.

[0089] For each tested product, one aluminium (AA 6014/3) panel was first coated and then two paint layers were applied (Kilate AcriTec Satinated water-based Paint from AkzoNobel), and it was left for about 1 hour to dry. 1 ml of lubricant was applied on the painted panel surface using a dropping pipette and the appearance was observed after 90 min and after 48 h.

[0090] No colour changes were observed with the lubricant compositions of the invention (Examples 1 and 2).

3.5. Dirt repelling

[0091] A dirt repelling test was performed according to the following steps:

1. A standardized sand mixture was prepared using sand plant (fertilizer) and coarse aggregate in a weight ratio 1:10 and was filtered through a stainless-steel sieve of 0.5 mm mesh.
2. A steel panel of 90 x 50 x 1 mm was carefully cleaned with hexane and was weighed before the lubricant application.
3. A surface of about 3/5 parts of the panel surface was delimited with marks, and 4 to 6 drops of sample (lubricant) were applied using a pipette and were spread in order to cover all the marked surface in the panel. The lubricant excess was drained with paper by capillarity.
4. After the lubricant application, the panel was weighed.
5. Sand was applied using a spray gun controlling the pressure at, 2, 2.5 and 3 atm for 3 seconds each application, 3 times for each pressure.
6. After the test, the panel was weighed again and the amount of sand adhered to the panel was calculated.

[0092] It was found that 171 mg and 169 mg of sand remained adhered on the panel after the test for the compositions of Examples 1 and 2, respectively.

Claims

1. A lubricant composition comprising:

- a) 90-99.5 wt% of a base oil and
- b) 0.5-10 wt% of an additive;

wherein the base oil consists of a mixture of castor oil and a triester of trimethylolpropane with octanoic acid and decanoic acid.

2. The lubricant composition according to claim 1, **characterised in that** it consists of the base oil a) and the additive b).

3. The lubricant composition according to claims 1 or 2, **characterised in that** it comprises 94-99 wt% of base oil, preferably it comprises 96-98 wt% of base oil.

4. The lubricant composition according to any one of claims 1 to 3, **characterised in that** the percentage of castor oil in the base oil is comprised between 70 and 90 wt%, preferably between 75 and 88 wt% and more preferably between 78 and 85 wt%; and the percentage of the triester of trimethylolpropane with octanoic acid and decanoic acid in the base oil is comprised between 10 and 30 wt%, preferably between 12 and 25 wt% and more preferably between 15 and 22 wt%, referred to the total weight of base oil.

5. The lubricant composition according to any one of claims 1 to 4, **characterised in that** the percentage of octanoic acid in the triester or trimethylolpropane is comprised between 30% and 80%, and the percentage of decanoic acid is comprised between 20% and 70%, referred to the total amount of fatty acids in the triester.

6. The lubricant composition according to any one of claims 1 to 5, **characterised in that** it comprises 1-6 wt% of additive, preferably it comprises 2-4 wt% of additive.

7. The lubricant composition according to any one of claims 1 to 6, **characterised in that** the additive is selected from

an antioxidant, a corrosion inhibitor, an anti-wear additive, a viscosity improver, a pour point depressant and mixtures thereof.

8. The lubricant composition according to claim 7, **characterised in that** the additive is selected from an antioxidant, a corrosion inhibitor, an anti-wear additive and mixtures thereof.

9. The lubricant composition according to claim 8, **characterised in that** the additive comprises:

- an anti-wear additive in an amount comprised between 0.2 wt% and 3 wt%, preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition;
- an antioxidant additive in an amount comprised between 0 wt% and 3 wt%, preferably comprised between 0.2 wt% and 3 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%, relative to the total weight of the lubricant composition.

10. The lubricant composition according to any one of claims 7 to 9, **characterised in that** the antioxidant is selected from tocopherols, esters of gallic acid, citric acid, citric acid derivatives, L-ascorbic acid, ascorbyl palmitate, bis(disubstituted dithiocarbamates), dithiocarbamate esters, butylated hydroxytoluene (BHT), 2,6-di-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, 6,6'-di-*tert*-butyl-4,4'-butylidenedi-m-cresol, *mono-tert*-butylhydroquinone, 4,4'-methylenebis(2,6-di-*tert*-butylphenol), octadecyl 3-(3',5'-di-*tert*-butyl-4'-hydroxyphenyl)propionate, or thiodiethylene bis[3-(3,5-di-*tert*-butyl-4-hydroxyphenyl)propionate], butyl-octyl-diphenylamine, dibutyldiphenylamine, or dioctyldiphenylamine and alkylated phenyl alpha naphthylamines.

11. The lubricant composition according to any one of claims 7 to 10, **characterised in that** the anti-wear additive is selected from triesters of phosphoric acid or thiophosphoric acid, amine salts of acid phosphoric acid esters, dithiophosphates, methylene bis(dialkyldithiocarbamates), and sulfurized fatty acid esters.

12. The lubricant composition according to claim 8, **characterised in that** the additive comprises:

- an anti-wear/antioxidant additive in an amount comprised between 0.3 wt% and 6 wt%, preferably comprised between 0.5 wt% and 4 wt% and more preferably comprised between 1 wt% and 3 wt%; and
- a corrosion inhibitor in an amount comprised between 0 wt% and 4 wt%, preferably comprised between 0.2 wt% and 4 wt%, more preferably comprised between 0.5 wt% and 2 wt%.

13. The lubricant composition according to claim 12, **characterised in that** the anti-wear/antioxidant additive is a methylene bis(dialkyldithiocarbamate).

14. The lubricant composition according to any one of claims 7 to 13, **characterised in that** the corrosion inhibitor is a succinic acid derivative or an alkylbenzenesulfonic acid ester with an epoxidized unsaturated fatty acid.

15. Use of the lubricant composition according to any one of claims 1 to 14 for the lubrication of mechanical devices, preferably for the lubrication of bicycle chains.

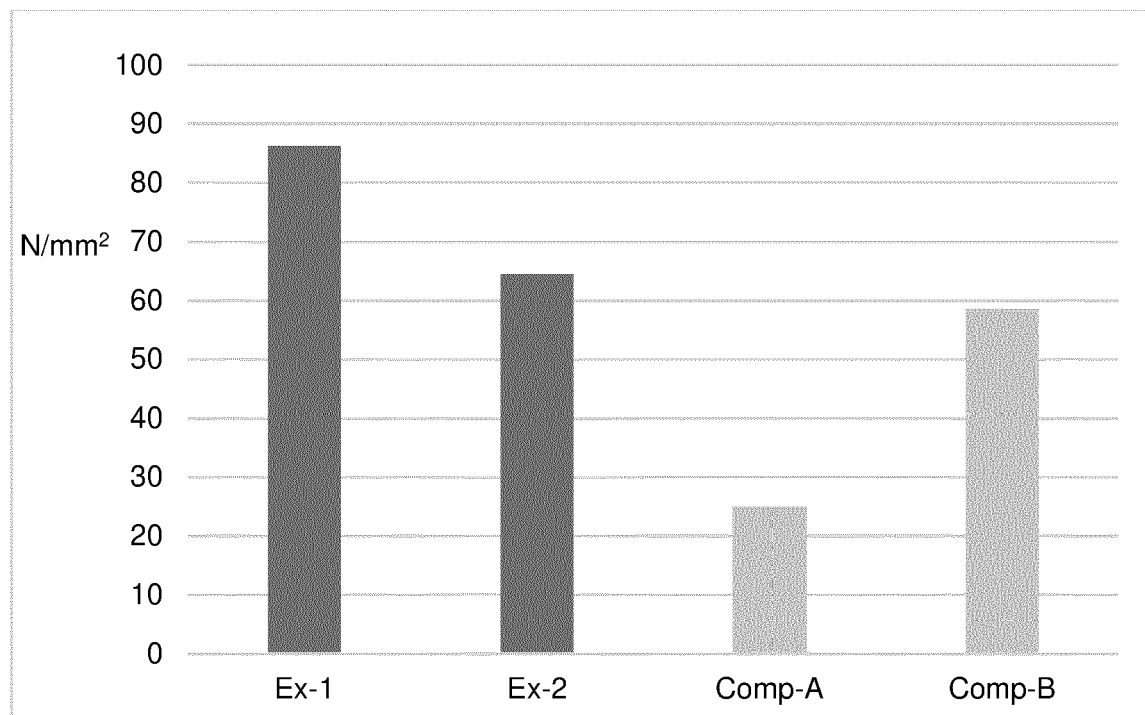


FIGURE I



EUROPEAN SEARCH REPORT

Application Number
EP 21 38 2335

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Place of search Munich		Date of completion of the search 6 September 2021	Examiner Kaluza, Nora
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